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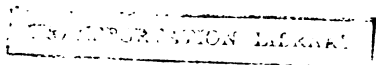
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ARTES SCIENTIA VERITAS

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ON  
**ASPHALTE ROADWAYS.**

BY  
**M. LÉON MALO.**



FROM A PAPER  
READ BEFORE THE SOCIETY OF CIVIL ENGINEERS AT PARIS.

TRANSLATED BY J. HENDERSON.



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ON

# ASPHALTE ROADWAYS.

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MEETING OF THE 20TH FEBRUARY, 1885.

I.

It is a phenomenon as well known as it is difficult to explain, that the more space there is accorded to the Parisian traffic, the more that traffic is increased.

Hardly have they opened a great artery, than it is already insufficient, without the parallel arteries having experienced appreciable relief. Since the Boulevard Sébastopol was constructed, the Rues Saint Martin and Saint Denis are more crowded than ever. On opening the Avenue de l'Opéra, the neighbouring streets were no freer; although the official returns showed in the new street a daily traffic of 35,000 vehicles. The continuation of the Rue de Rivoli has not diminished in the slightest

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the bustle in the Rue St. Honoré, quite the contrary; and yet the municipal statistics reveal to-day, in this same Rue de Rivoli, at the corner of the Rue du Louvre, the enormous number of 42,000 vehicles during the twenty-four hours.

How shall this growth be stopped? With what materials shall the public highways be strengthened in order to resist this torrent, every day more threatening to the roads? From whence will they take these materials? How will they employ them? Such are the serious and abstruse questions which do not cease, they say, to occupy so acutely the municipal government, and certainly not without reason.

One can well understand, besides, the number of new experiments tried lately, with the view of replacing, by methods less barbarous, the modes of paving that have been bequeathed to us by our forefathers. An equal sign can be seen in the visits recently made to several foreign capitals by the engineers in the service of the municipality; fruitful visits moreover, as shown by the very solid and very interesting report that the chief

engineer M. Barabant has published on his notes brought back from London. The subject is the order of the day, eminently real and pressing ; it bears with considerable weight on the conditions of well-being, the comfort and the healthiness of the city of Paris, and on the economy of its budget ; and has therefore a decided place in the discussions of our Society.

Whether it be an advantage or a misfortune, it is certain that our desire for progress never ceases to increase ; we are greedy for improvements, each day must bring its own, without which we believe we are receding. The numerous discoveries which, in the last quarter of a century, have transformed the conditions of the well-being of the public, have rendered us insatiable. The public highway ought to adapt itself to these exigencies ; a system of roadways, which nevertheless was at its beginning considered a beneficent importation, has recently been cast aside ; l'empierrement, better known under the name of macadam, has been abolished throughout the whole central part of Paris.

The suppression of this system has been favour-

ably received by the framers of the town's budget, firstly, because this ruinous roadway had overweighted the finances, and next by the street inhabitants who for a long time had submitted to it as a nuisance. It has been replaced, hurry-scurry, by a newly arrived process, already applied with varying fortunes, in several large foreign towns; I allude to wood paving. Cautious people consider that it is perhaps a little rash in taking up this innovation, precisely when it is being repudiated in some foreign countries; but the material was at hand, there was a hurrying to get rid of macadam, and it was necessary to walk on something. At this critical hour, compressed asphalte, by a chain of circumstances of which I shall say a few words shortly, had just passed through trials which had put it in a delicate position with the Parisian population; it is thus easy to explain the sudden and to a certain extent merited demand which hailed the appearance, three years ago, of the revived and improved wood paving. To supplant macadam was for wood already a sufficient title to public favour. The future will tell if the proportions of the experiment have not been, from the first hour, somewhat exaggerated.

Be that as it may, it must be acknowledged that some sound merits recommended it to the engineers and architects. Amongst these merits, the most important, in my eyes, was that in accordance with the principle, too long slighted and on which should be based all future systems of paving employed in populous quarters, if it is intended to withstand the accelerated increase of the Parisian traffic, the most wearing in the world ; that is, the principle which consists in substituting for a hard matter, like stone paving, a substance comparatively elastic resting on a firm foundation and intended to play the rôle of cushion between the wheels of the vehicles and the resisting concrete of the roadway.

On these grounds, above all, wood ought to be challenged to prove its efficacy by the side of asphalte, already in possession of so many public streets, and demonstrate by its use the truth of the principle I have just enounced ; and, though the trial-surface appears to have been extended more considerably than perhaps common prudence permits, we ought to congratulate ourselves on this new advance towards the suppression of hard and noisy roadways, which will follow sooner or

later, but certainly, the already accomplished expulsion of macadam.

It is not in Paris alone that there is anxiety as to the progressive development of the traffic, and of its influence on the preservation of the public highways; the book of M. Barabant informs us that in London the application of new systems is multiplying, asphalte and wood at the head. Asphalte especially, which not having been badly worked in London as it has recently been in Paris, is deemed in the opinion of English engineers the roadway of the future.

“In London,” says M. Barabant, “the success of the asphalte may be considered as almost complete;” and further on, “Colonel Haywood, whose opinion is of such great weight in these matters, does not conceal, that in his opinion asphalte is the best facing for roadways, at least for the City.” It was well to seek from the foreigner this rehabilitation of asphalte so pitiably maltreated at home. M. Barabant has related to us in this chapter the sentiments of the English. After a study, less complete it is true, and less profound than his, I have

recently brought back those of the German engineers, and I believe it will be useful to make them known.

Before speaking of them, I ought to explain here, in order to make clear that which has preceded and that which is to follow, how, for five years, from 1877 to 1883, the construction and maintenance of the asphalte roadways of Paris had been by an unfortunate decision withdrawn from the company who had introduced and acclimatised them in France ; how, in leaving its hands, they had fallen by the hard law of lowest tender into those of a society of which it will suffice to say, that after having deplorably contaminated these roadways by employing suspicious materials, it has finished by a big financial catastrophe, leaving to those whom it had supplanted the unenviable task of remedying the evil done.

These things are of notoriety in the world of public works ; that is why I speak thereon without more reserve. For eighteen months the new contractors have worked to remove the consequences of this costly mistake, they had the task in con-

sequence of reconstructing last year from end to end, the Rue de Richelieu, and other streets, at the same time that they have maintained the old streets in as good a condition as possible under the circumstances. But this is a long story, and the public, which is not accustomed to inquire into the cause of things which offend it, has naturally retained a disagreeable impression of the affair.

This momentary and partial eclipse of asphalte in Paris has evidently helped to open wide the door to wood paving, and I am the first to recognise that we ought to congratulate ourselves upon it. When the last hour of stone paving shall have struck, these two auxiliaries will not be too many to replace it. Each of these systems has its distinctly marked place in the Parisian public highways. Wood, if the vast experiment that has been made really succeeds, will remain suited for the paving of wide places exposed to the air, asphalte for narrow streets, where wood, with its spongy nature and its propensity to absorb moisture, would, if it were imprudently increased, cause great prejudice to the public health. The cities of London, New



York, and Washington were the first to make this disagreeable discovery; we ought to profit by their mistakes.

Be that as it may, it now appears certain that the roadway of the future will necessarily be an elastic and noiseless roadway, and at the same time durable. Stone paving is not strong enough to resist the destructive traffic that it has henceforth to bear. If it is simply laid on a layer of coarse sand, as heretofore, it quickly gets out of order, becomes uneven, and ends by presenting inequalities of such a nature that the wear and tear of the vehicles is greatly increased.

If it has for a foundation a bed of rigid concrete, as has been the practice lately, it becomes horribly hard and noisy; without taking into account that, in certain very crowded streets, it becomes crushed between the unyielding foundation and the wheels of the vehicles, it cracks, sometimes is pulverised, and necessitates thereby frequent repairs. The days of paving setts then are numbered; when trials of sufficient duration shall have pointed out the best elastic roadways, asphalte, wood, or others yet

unknown, the paving of King Philip Augustus will go to rejoin macadam in the suburbs and on country roads.

This critical situation has naturally led specialists to cast their eyes around them to seek for and to utilise the experience of others; hence the works which I have mentioned above. I have myself been able recently to take some notes in Germany that perhaps are suitable for throwing their modest share of light on this great question. I believe, then, it will not be useless to recapitulate them here. It is not that I have discovered there anything particularly new, anything, so to say, created, the greater part of the methods employed on the banks of the Spree have come in a direct line from those of the Seine or the Thames; but, in copying them, the Berliners have produced works so careful, so methodical, and so conscientiously studied, that we can regard them almost as innovations, and bring back with profit the practice among us.

## II.

No one can be ignorant that in the last fifteen years the city of Berlin has extended and embellished itself with an expansive force hardly credible. It would be too painful, and moreover superfluous, to recall by what train of circumstances, by means of what resources it has procured this rapid prosperity. It is not necessary to wander into inquiries of this description, if one wishes to approach with the coolness and the impartiality befitting science, the study of those things which are the object of this work.

This is certain, that the Berlin Public Roadway authorities must have had some trouble to follow, in its unheard-of development, this spread of a city, the population of which has doubled in twenty years, and the traffic of which has increased in the same proportions. It has attained, however, thereto, and we Frenchmen have done something to help them with our ideas as well as with our war indemnity.

Some statistics first, in order to establish the elements of the debate :

In 1876, that is to say at the time when the maintenance of the roadways passed from the hands of the State into those of the city, the capital of Prussia had 4,476,000 square yards of public highways, that is to say :

14,400 square yards of stone paving merely laid on sand, but nevertheless pretty well preserved.

4,018 square yards of stone paving knocked out of shape by the traffic, imperfectly maintained, and of a literally frightful appearance.

432,000 square yards of macadamised roadways.

12,000 square yards of compressed asphalte.

At the present hour, they count there

450,000 square yards of stone paving laid on a very solid foundation, with joints of sand and bitumen, as I shall describe later on.

654,000 square yards of stone paving laid on a simple bed of coarse sand (in the streets where the traffic is slight) and maintained notwithstanding in good condition.

3,705,600 square yards of very defective stone paving, laid cheap in districts in which the drainage works are not yet executed, consequently sure to be replaced some day or other.

579,600 square yards of macadamised roadways, principally in out-of-the-way quarters and in the Thiergarten or Zoological Gardens, the Bois de Boulogne of Berlin.

384,000 square yards of compressed asphalte roadways.

48,000 square yards of wood paving.

The re-formation of the public highways of Berlin is entrusted to an engineer of great merit, M. Rospatt, who has devoted himself less to do grandly and rapidly than to do solidly and durably. He is assisted in this by an able colleague

M. Gotheiner. It will cost my patriotism nothing to declare that if in many circumstances they have borrowed from us the first ideas of their improvements, we might imitate, without harm, their methodical study of detail, the perfection, in even the smallest particulars, of their manners of working, I would almost say their procrastination; all qualities which would come in time to counter-balance the ardour and impatience of our national character (in our public works, I mean).

Here are some special remarks upon the materials actually employed by them in the public highways of Berlin.

The ordinary paving stones are of Swedish (Karlskrona) granite, except some thousands of metres of Belgian porphyry. The paving stones arrive at the site of the work all examined and ready for laying. The Swedish granite is from  $7\frac{1}{2}$  in. to 8 in. in thickness, the Belgian porphyry from 6 in. to  $6\frac{1}{4}$  in.

The method of laying most generally followed is this: on the subsoil a first layer of 4 inches of broken

granite is spread, then a second bed of the same granite, crushed smaller. This total bed of 8 inches is forcibly compressed by means of a fifteen-ton steam roller, after which it is covered with a thickness of 1 in. to  $1\frac{1}{4}$  inches of river sand. Above this is placed the dry stone, with joints from  $\frac{3}{8}$  to  $\frac{1}{2}$  inch, which are filled about half the height with fine gravel; the remaining space receives a mixture of pitch and creosote. This is exactly the system now in use in the principal streets of Liverpool. Beneath the tramway lines, whether the roadways be paving stones, asphalte or wood, the foundation is always made of Portland cement concrete.

I would point out here that the paving setts, granite or porphyry, employed at Berlin, are divided into three categories.

The first class, reserved for those streets that are definitely finished, is a perfect parallelopiped.

In the second class, the lower surface of the stone is equal to four-fifths of the upper.

In the third, it is two-thirds.

When new streets are opened, a roadway is improvised with paving stones of the second or third class, laid on a bed of ordinary gravel 8 inches thick; these are only replaced with a paving of the first class when all the arrangements of the subsoil, sewers, water and gas pipes are completed—*ne varietur*—and that no disturbance of the earth is to be feared for a long time. We shall have perhaps also to borrow some of this foresight.

At Paris, the exigencies of the new works or repairs oblige too often the authorities of the public highways to disturb the roadways, sometimes only finished the previous evening, to the great prejudice of the economy of the budget and of the solidity of the facing. This method of working is not only expensive, it necessitates the cutting out of the asphalte or the wood, and what is more serious even the concrete, and thus creates causes of depressions without number, the rubbish from these trenches not being able naturally to settle like the rest of the ground.

It is greatly to be desired that at Paris, as at Berlin, the gas and water pipes could be laid



under the footways. The appearance of the roads would be more satisfactory.

Stone paving on concrete has little sympathy at Berlin. Its hardness and noise are dreaded.

The first serious essay of wood paving tried at Berlin dates from 1879. At this time, the roadway of one of the fine streets, near the Opera, was constructed by the Wood Company, the same which introduced the system to Paris, four years ago. This first specimen had to be taken up last summer, in order to replace it with compressed asphalte. Although laid under excellent conditions, on a very solid cement concrete, in a street with light traffic, this paving was changed into a slough at the end of five years. The blocks of wood had rotted, and worn in a very unequal manner, to such a degree that, to evade the jolting, carriages had ceased to pass through the street.

In the construction of this roadway, which has disappeared, Swedish pine was used. Different companies, coming afterwards, have tried other substances ; Bohemian pine, injected with creosote, pitch

pine, yellow pine, cypress, with or without injection. That which remains of these latest essays, about 48,000 square yards, is still too recent to be able to furnish conclusive results; however, it has been remarked that the pavements abundantly injected, the only ones that do not rot in the climate of Brandenburg, have not had a better fate than those which are not injected at all. Whilst these perish by the damp, the first, during the fine season, allow their creosote to escape, which forms on the surface perfect puddles of tar. The heat of July is as violent at Berlin as the cold is severe; during the months of summer the town was infected; the inhabitants could not bear the smell diffused by the creosote, and clamoured for the suppression of the unfortunate paving. Wrongfully, certainly; because, besides that this excess of creosote thrown off by the paving was a guarantee of perfect impregnation, and consequently of durability; its antiseptic virtues should have caused it to find grace in the presence of a densely crowded population, for whom the dangers of an epidemic are infinitely more formidable than the odour more or less disagreeable but purifying of the creosote. In short, for various reasons, the 48,000 square yards of wood

which remain at Berlin are looked upon with an unfavourable eye by the public and by its engineers ; the disappearance of this system of paving appears to be little more than a question of time.

Asphalte has been more fortunate. It must be said that it has shown itself up to the present time to be irreproachable (December 1884), and that the annoyances which it has, although innocently, caused the Parisian public, have been avoided here, thanks to the initiative of the engineers of the Berlin public ways, who, not being like those of Paris, impeded by the law of the lowest tender at any risk, have been able to choose of their own free-will contractors and materials. Compressed asphalte is definitely acclimatised at Berlin, which contains to-day a surface larger than that executed at Paris during twenty-five years, and, in consequence of the foresight of the municipality, it is destined to cover, sooner or later, all the fashionable streets of the German capital.

Naturally the engineers and contractors of Berlin, and also the English engineers, in introducing into their own cities a roadway system which was in-

vented, studied and experimented on in France, have borrowed from us our ideas, our processes, our practice, our tools, our workmen, all the special technicality laboriously created by us during a quarter of a century. A legitimate borrowing, however, and of which we ought not to complain; for whilst, for the reasons explained above, we left in jeopardy this valuable element in the embellishment and sanitation of towns, the Germans, profiting by our studies and devoting themselves to the avoidance of our faults, have arrived at results which have saved the honour of asphalte, compromised in our hands by the most sad mismanagement. The 384,000 square yards of compressed asphalte which exists at this hour in Berlin and forms the nucleus of a general transformation of the public roads, does not show a single one of those black and gaping holes which, in these latter times even, have disgraced the most beautiful streets of Paris. If some partial defects have shown themselves in certain streets, they are due to local causes with which they will certainly disappear. The engineers there have their hands free; they have the right, by their capacity and according to their conscience, of choosing the best body of contractors and the best

materials, without troubling themselves about the often fallacious advantages of excessive cheapness. They therefore know what they are doing, and assume entire responsibility. They are not obliged, as ours have been recently, to allow to be introduced into the street, against their will, materials of bad quality, and to see the municipal cashier afterwards pay for this strict observance of an absurd law, an amount which I would rather not state.

There are employed on the roadways of Berlin, asphaltes from four different sources :

Val de Travers.

Seyssel.

Ragusa (Sicily).

Limmer (Hanover).

It will be understood that I do not adjudicate any more on the respective merits of each of these materials than on the relative ability of the contractors who apply them. First, because I do not intend to mix the appreciation of people and commercial competitions with this entirely technical study; next, because the materials employed have not yet given, at Berlin, the exact proportion of

their respective values. The asphalte of the Val de Travers, the first that was introduced, and consequently the most widely spread within the city, shows, during the extremely hot weather, a propensity which it manifested at Paris before they conceived the idea of mixing it with the Seyssel asphalte, of becoming soft under the wheels of vehicles and forming as it were waves, which the return of the cool weather causes promptly to disappear. At Berlin, where this mixture has not taken place, the waves are produced each summer with a certain persistence, but as they have not caused any appreciable damage to the roadways, the public and the engineers have thought little of them.

The Ragusa asphalte presents the same inconveniences; I have not heard that they have been less inoffensive.

As for the Seyssel asphalte, its small percentage of bitumen completely preserves it. More difficult to work than the other two because of its relative poorness, this difficulty at the same time requires that the greatest care should be brought to its

application, and, especially to its heating, the very greatest regularity. But, laid under these conditions, it gives a roadway of a hardness much greater than that of the others, and consequently exempt from those waves and soft places, certainly more unpleasant to the eye than really injurious, which are produced with asphaltes too rich in bitumen.

It must be acknowledged that this success of the compressed asphalte at Berlin has been powerfully assisted by the extreme strictness with which the preparation and the laying of the concrete are carried on and inspected. This concrete from 8 in. to  $8\frac{1}{2}$  in. in thickness, constitutes an indestructible foundation. I have seen a layer cut up in order to construct a tramway, it might have been called a monolith of granite. In order to make it, a proportion of 312 lbs. of Portland cement is employed of the best brand, to one cubic yard of that which the Germans, using an English phrase, call "ballast," that is to say a mixture of pebbles and rather fine sand, obtained from the hills, the ancient downs, which surround Berlin. The asphalte is only laid on perfectly set and

thoroughly dry concrete; thus preventing the production of steam, caused by spreading the asphalte powder heated to 248 to 266 degrees Fahrenheit on a damp surface; steam which, in escaping, cuts through the asphalte crust, destroying its homogeneity. A great part of the deteriorations, it is proved without doubt, at Paris, from the time of the first application of compressed asphalte, was caused by the disregard of this absolute rule which the Germans observe with the greatest care. The householders on both sides of the street show, moreover, the necessary patience; they like better to suffer a fortnight or more of block in their street, and to be assured that the roadway before their houses will never have to be repaired.

To sum up, the vast experiment made at Berlin, with compressed asphalte, has succeeded beyond the expectations of its originators and its users themselves. It required from the German engineers strong faith, and a thorough knowledge of the reasons of the recent failure of asphalte in Paris, to give to this experiment the importance which it has developed. They had, it is true, the reassuring example of similar works executed in London



under identical conditions with similar results. Their spirit is none the less praiseworthy.

This double and categorical demonstration proves twice over that the ill-luck of the asphalte in Paris arose from causes absolutely independent of the system itself. At the point where we now are, and as I showed in the first part of this work, it is important to know for certain if asphalte be or not a resource on which the Parisian public highways committee can now count, or, on that day when stone paving having failed and wood paving becoming insufficient, it will find itself run short. For whoever has seen and studied closely the roadways of London and Berlin, no reply is necessary.

Furthermore, the works which have been executed in Paris for nearly two years with the view of restoring to a good working state the asphalte roads compromised by the annoying circumstances that I have related, have also, already, brought their contingent of proofs.

The roadway of the Rue de Richelieu, for example, reconstructed eighteen months since,

according to right principles, and subjected as every one knows to a terrible traffic, has not required the slightest repairs. Several other roadways relaid more recently (Rue St. Honoré, Rue Richer, &c.) have furnished similar results, and there is no occasion to think that this state of things will not last, for it is an invariable experience that if an asphalte roadway is to break up before its natural life, it is always in the first six months that it commences to deteriorate.

### III.

From the foregoing, we may, I think, be authorised to draw the following conclusion—that asphalte and wood can and ought to exist in Paris in harmony, without encroaching on one another's domain. It is a mistake for certain commercial interests not founded on a proper basis to excite rivalry between themselves. It is neither sensible nor advantageous to any one. The two systems of paving have, as I said just now, a quality in common, that of offering to the rolling of the vehicles a smooth and relatively elastic sur-

face ; but their inherent properties are perfectly defined and differently utilisable. The one and the other have their marked position in distinct portions of the public roads, and it would be an economical error not to employ them.

I do not intend here to strike a balance of their respective merits ; but without detracting from one or the other, it may be said that, if the wood is an embarrassment for public hygiene, asphalte is an auxiliary thereto. It is on this special and principal point that I wish to insist.

Wood, I repeat it, appears to be suitable to large areas of traffic, such as the avenue of the Champs Elysées, that of the Opera, the great Boulevards where the atmosphere, circulating in abundance, drives away miasmata, and rapidly dries up the surface soil. There, the special disadvantages of the wood are diminished, and are certainly balanced by its advantages. If the important experiment which is now being made in Paris succeeds as it is to be wished, that is to say if the wood paving remains after a certain number of years' use in the state in which we see it to-day,

we ought without doubt to consider it as a fortunate innovation.

But, on the distinct condition that it will not go beyond there, and will not attempt to penetrate into the narrow and almost deprived of sunlight streets, in those, above all, whose situation as regards the cardinal points of the compass is such that it screens them from the action of prevailing winds. Those streets which are still furnished with the old sandstone setts, are now accumulators of moisture and of unwholesome smells which in a city where the population is as crowded and as dense as in Paris, cannot have other than a deplorable influence on the public health. It would be certainly another danger if they introduce there as a coating for the roadways this immense sponge which is called wood paving.

The imprudence would be so much the more serious that Paris has never had more want of the little pure air which it breathes. Whilst the human mass accumulated on this small geographical point was increasing in enormous proportions, there was a suppressing everywhere of private gardens, those laboratories for the purification of

the atmosphere, in order to substitute houses let off in flats for them. This last half century has seen disappear little by little this revivifying verdure, and new sources of putrefaction have taken their place. The municipality has, it is true, done its best to multiply public gardens; a Board of public gardens and promenades managed with great ability endeavours to procure for the breathing of Paris the oxygen that the suppression of the private gardens had so deplorably diminished; but all this ability, all these efforts will be in vain if the poison chased with so much trouble from the atmosphere, by the opening of streets, by shaded squares, by a superabundance of watering, is allowed to secrete itself in the surface soil. To introduce into the half-dark streets this new condenser of miasma would be to open wide the door to those epidemics which it has cost so much pains to banish by so many and so costly sanitary measures.

This is not merely a matter of speculation; the foreign cities which have preceded us in the employment of wood paving on a large scale have given us indications on this subject that we should

take care not to neglect. The experiences of Washington, Philadelphia, Chicago, those of London, and finally of Berlin, are there for our edification. At the same time, the censure that I pass on wood paving is not without restriction. I recognise its grand qualities ; if it resists in a proper manner the Parisian traffic, if it is employed with prudence, under conditions harmless to the public health, it will have no advocate more convinced than I. The Berliners were wrong, in my opinion, not to tolerate it in their principal avenue, Unter den Linden ; if the humidity of their climate is opposed to that which they employed there, the unimpregnated pine, it is a pity that they had not at least patiently borne the odour from the paving thoroughly impregnated with creosote. I commend them, on the other hand, for having excluded the wood from the small adjacent streets, where it had been a permanent focus for infecting the air. Between the system which absolutely proscribes wood paving and that which consists in laying it everywhere, there is a middle course, which is to choose with discernment the points where it can be placed without danger, and not to go beyond ; this is the position that ought to be taken in Paris.

A German engineer, who has treated with competence these questions of paving — Professor Dietrich, sent by his Government to all the capitals of Europe and North America in order to study the subject on the spot, has published quite recently a report which explains the antipathy of his compatriots for wood paving. He has collected the mistakes experienced in the large cities of the United States, and has exposed them with a certain malicious pleasure. He made a list fit to frighten the municipalities which did not know in what a summary fashion the Americans work. When he showed the paving of Chicago, transformed at the end of three or four years into an immense slough, he evidently did not seek to encourage his fellow-citizens in the adoption of a process which could give such results. This estimate by a savant considered in his country as an authority in the matter, is without doubt the cause of the bad reputation acquired by the wood paving in Berlin; very probably, the fear that this eminently water-absorbing substance had a disagreeable influence on the public health has impelled M. Dietrich to exaggerate the misdeeds of wood paving. Americans do not bring to the execution of their

works the minute care and extreme attention that Germans give to theirs; if their wooden roadways have so promptly rotted and deteriorated, it is probably because the substances employed by them were badly chosen, insufficiently impregnated, that the laying was defective, that their concrete was too thin, and that it was made with cement of a bad quality; it is thus that this concrete, being only able to offer a feeble protection against the dampness of the subsoil, the blocks of wood rotted simultaneously above and below. In no matter what climate, such a work would have been condemned in advance to rapid destruction.

In Paris, on the contrary, the laying of the wood paving has been done with ability and extreme precaution. It has been given such a solid foundation of cement concrete that the asphalte layers have envied it, and so have finished, moreover, by obtaining the same foundation as it; asphalte has at least gained that much from the importation of wood paving. It may be stated that the wood paving of the Boulevard Poissonnière, of the Champs Elysées, and the Avenue de l'Opéra has been executed with an unusual perfection. Therefore, if



it should succeed anywhere it will certainly be in Paris.

Will it succeed there? That is the secret of to-morrow. Under the reservations that I have pointed out, it is to be desired; two systems of luxurious paving at Paris are not too many, but I insist on this capital point, wood should be absolutely banished from the narrow streets, which all belong to asphalte. Until another more efficacious process be discovered, the compressed asphalte will remain the hygienic roadway *par excellence*; with all the qualities which it aspires to show, wood paving cannot, on this point, enter into competition with it. It will suffice to see, after rain, the appearance of the one and the other; where they are juxtaposed, the contrast is curious to note. At the end of half an hour of fine weather, asphalte is completely dry, whilst wood remains soaked with the water which serves as a vehicle for imbibing the dirt of the street, the horses' urine, and all the impurities of traffic; these matters penetrate into the fibres, producing there a kind of fermentation, and, when the sun comes next, by evaporation, to restore them to the atmosphere, they reappear in

the state of nauseous miasma, admirably adapted to create epidemics. It is above all when the fibres of the wood have taken, through wearing out, the particular form which makes them resemble an old tooth-brush, that this propensity to absorb and to exhale unwholesome liquids manifests itself with the greatest energy. New wood paving lends itself less easily thereto.

I do not attach to this disadvantage a greater importance than it merits. It only reveals itself in a mild manner on surfaces well exposed to the air; but suppose they had paved with wood the Rue de Richelieu or the Rue Neuve-des-Petits-Champs, the next cholera epidemic would certainly not have found a more powerful fellow-labourer.

It would then be puerile to seek to make of wood and asphalte two adversaries ready to struggle for the acquisition of the paving of Paris. Both, I repeat it once more, have some qualities in common, noiselessness, the freedom from jolting, and cleanness; both have their peculiar faults; perfection in roadways, like other things, is not of this world. But, if any one wishes to judge im-

partially, they should recognise with me two things ; the first is that, despite the bad usage during late years, compressed asphalte has, behind it, at Paris a past of twenty-five years, at London of fifteen years, at Berlin of ten years, and that each time it has not been badly laid by its workmen it has everywhere succeeded ; the second is that it is for the public hygiene, by its hydrofugic properties, and its absolute impermeability, an indisputable and precious auxiliary. Whatever sympathy is professed for wood paving, and to the extent that I have pointed out it has mine entirely, it is impossible to accord to it in an equal degree the two merits of which I have spoken. Let it seek to limit its ambitions ; its career will then be surer and longer. It will be better for it to be contented with the part, already perhaps excessive, which has been made for it in the Parisian public ways, than to run the risk of seeing itself, at the end of some deadly epidemic, the victim of a scare such as sometimes happens unexpectedly to decimated populations.

I have been persuaded, as the oldest perhaps and certainly one of the most assiduous amongst the

specialists of asphalte, to present to the Society these observations, to which peculiar circumstances of municipal interest lend at this moment a really serious character. It has seemed to me that an incident like that which has during five years given up the maintenance of the asphalte roadways of Paris to unskilfulness and defective workmanship, cannot prevail against the qualities, publicly established without doubt all over Europe, of a system which could become, any day, for the Parisian public roadways such a valuable resource, and which, however, has nearly fallen a victim to a refusal of justice. I have thought that it did not become me to plead its cause, that is its affair to defend itself by its results, but to establish its true position. Kindly forgive me, for the sake of the intention, for going to seek, for my opening out of the question, some arguments even from Berlin.

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M. Dallot wished to put a question to M. Malo, as regards the employment of asphalte on the sloping parts of roadways.

M. Malo had just acknowledged himself that in

return for its advantages, asphalte had one inconvenience, the tendency to slipperiness when its surface is damp. This inconvenience which is trifling and endurable, after an already long experience, for a nearly level roadway, appears to become serious if it concerns a road on which heavy vehicles circulate and on which the longitudinal plan is very irregular. What is the solution to adopt in such a case?

M. Léon Malo said that the effect of the slipperiness accentuated itself more in the inclined parts; he is of the opinion that, beyond a certain incline, it is inconvenient to employ asphalte. Each system has its advantages and its inconveniences, and the inconvenience of the slipperiness, in the case of the employment of asphalte, is, he acknowledged it, as much greater as the gradient is steeper; but only during a very small number of days in the year. Besides, a sluicing ever so little attended to will abolish at once and in an absolute manner the inconvenience of the slipperiness.

M. Dallot asked what limit of slope it was possible to allow.

M. Léon Malo said that with an ordinary sluicing he would not hesitate, for example, to employ asphalte on the Boulevard Poissonnière, but he would not go further, and he would not recommend it for a steeper incline. Moreover, the horse slips, this is evident; but if it fell on the asphalte, it would be hurt less than on paving stones. That which is most dangerous, in point of slope, is the convexity of the roadway. At first, when they made asphalte roadways, the engineers, probably from an æsthetic point of view, wished to give to the asphalte the same camber as to the paving stones; it was some years before this convexity was suppressed, and that only just that transverse incline was given that was necessary for the flowing away of water. When there is too great convexity, the horse slips a great deal because it recedes from him. The lateral slipping is very dangerous for the horse. Since the convexity has been suppressed, this inconvenience has nearly disappeared.

M. Dallot inquired if, on an incline like that of the Boulevard Poissonnière, which starts from the crossway Montmartre, the startings are not difficult

for the heavy omnibuses which circulate on this route when the roadway is damp.

M. Léon Malo replied yes, when it is damp with greasy mud ; not, if it is damp in consequence of a washing or of a fresh rain. It happens on perhaps fifteen or twenty days in the year that a small fine rain falls, and forms a kind of slime on the roadway ; if washing does not follow, slippings are to be feared ; but each time that the roadway is dry or well washed there is no slipping there.

M. Périssé asked what is the price of a pavement such as that which is presented to us, which appears very remarkable, very hard and very resisting, with a bed of cement concrete, for M. Malo had said that the cement concrete was imperative.

M. Léon Malo replied that that depends on the thickness of the concrete ; at present, in Paris, the beds of concrete were made 6 in. to 7 in. thick.

M. Périssé asked if, definitely, this paving is more or less dear than wood paving.

M. Léon Malo replied that it is certainly less dear.

M. Seyrig said that there is a question, at this moment, of a new paving tried at Berlin, and which, if he is well informed, would consist of bricks or ceramic material impregnated with asphalte. He had no information on this point, and asked M. Malo if he could give us some remarks on this new method of paving.

M. Léon Malo believed it was a simple deception. This is the system. All kinds of porous matter can be impregnated with asphalte. The inventor of this system (which, moreover, has never been applied at Berlin, save perhaps during a few days) believed that in introducing bitumen into the brick, he would give to that brick the properties of asphalte, and would communicate to it a sort of elasticity. That which gives the elasticity to the asphalte is the agglomeration of its grains of limestone stuck together by the bitumen. The inventor in question thought that he would obtain this elasticity by simply introducing some bitumen into the brick. This was a gross mistake. If



bitumen is introduced into a brick, as into plaster, their molecular constitution is in no way changed ; if the bitumen is taken away, the brick and the plaster will resume the same condition as formerly ; whilst if the bitumen be removed from the asphalte, this falls into powder. The bitumen which, by its presence, gives elasticity to the asphalte, does not give and cannot give any to the brick. M. Malo repeated that, according to him, the system spoken of had not been applied at Berlin, or if it had been tried, it had been immediately suppressed.

M. Lebrun wished to ask M. Malo if he could, in the account rendered, give an idea of the price ; it would be a useful completion of his communication of to-day. It would be interesting to have the prices of the system at Paris or at Berlin, according to the thickness of the roadway.

M. Dallot asked if a thickness of 6 in. of concrete is not too weak for a heavy traffic.

M. Léon Malo replied that in the busy streets it

is insufficient. At Berlin they always put a thickness of 8 in. to  $8\frac{1}{2}$  in.

The President thought that if M. Malo would be so obliging as to add to his communication a small table indicating the prices at Berlin and at London, he would render a service to the Society.

M. Léon Malo would very willingly add this information; he had not made it to-day, in order not to introduce too many figures into his communication.

The President asked if there were not any more remarks.

M. Noblot said that the slipping of the horses was much insisted upon; he asked if they had not tried to groove the asphalte to form rectangular pavements, with the view of diminishing this inconvenience.

M. Léon Malo replied that the grooving was only employed for the entries to coach-houses, and could not be made on the roadways, because it

is contrary to the very principle upon which the system is founded. It is, actually, the vehicles which effect the compression, commenced at the moment of laying by the rammers and the rollers, and the grooves would have disappeared at the end of a fortnight. Care should be taken not to throw sand on the surface, because the sand will penetrate to the interior and deteriorate the asphalte crust.

M. Malo ought to make the remark that the compressed asphalte does not permit of the introduction of any foreign matter. It is, he repeated, a relatively elastic material that the circulation of the vehicles compressed without ceasing; the older the asphalte is, the harder and more solid it is.

The President thought that, in stables, the grooves would not be an inconvenience, because there was not this compression that was just spoken of.

M. Léon Malo replied that, in stables, compressed asphalte was not generally laid, but mastic asphalte like that of the footways, of which the

grooves are moulded, and which better resists the horses' feet.

The President thanked M. Malo for his very interesting communication, which it became him to make as one of the oldest and one of the most persevering promoters of the employment of compressed asphalte; he thanked him so much the more as he had made the journey from Lyons expressly to read his work to the Society.

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#### MEETING OF THE 6TH MARCH, 1885.

The President called upon M. Molinos, who had some observations to present on the subject of the communication that M. Malo had made at the last sitting.

M. Molinos said that he had read with great interest the communication of his friend M. Malo on asphalte paving, on the advantages that it presented with respect to stone paving, and its comparison with wood paving.

M. Molinos is almost completely at one with M. Malo on the whole of the views that he had presented to the Society; he had nevertheless some reservations to make on the subject of certain indications relative to wood paving which M. Malo naturally could not be as well acquainted with as the question of asphaltes, on which his competence is without rival.

M. Molinos thinks, like M. Malo, that stone paving is doomed to disappear from Paris. They had only really, up to the present, considered in these questions one aspect of the problem—to insure as well as they could a roadway practicable for vehicles. But with our increasing exigencies in the matter of comfort, it is necessary henceforth to take into account another element, the harassing of the inhabitants by the insupportable noise produced by an increasing circulation on jarring roadways. In the narrow streets it is impossible to sit with the windows open, and this unpleasant and at the same time unhealthy state of existence it is necessary to endure during the whole of the fine season.

M. Molinos is therefore convinced that the future

belongs to those roadways which will join to the advantages of ease of traffic, like asphalte and wood paving, that of suppressing the din for the householders on both sides of the street. From this point of view it should first be observed that it is wood paving which up to the present best solves the problem. Any one can be satisfied that in narrow streets with a large traffic, like the Rue de Richelieu, for example, the asphalte resounds under the horses' feet sufficiently to still incommode the inhabitants, and render painful the abode in flats with the windows open. On the contrary, wood paving is absolutely noiseless. He would not then be able to agree to the division that M. Malo indicates of the narrow streets to asphalte, the large roadways to wood paving.

M. Malo said that wood paving appears to have been definitely condemned at Berlin. It is with wood paving as with asphalte. M. Malo has with reason recalled the history of asphalte in latter years, of the disrepute into which this system of paving has fallen in consequence of bad execution, the sequel of an unlimited competition. The same facts are produced at Berlin, where the works have

been entrusted without discernment to timber merchants without experience, who have executed them badly. We shall perhaps see in Paris, in a near future, the wood paving suffer failures, if they fall again into the same errors. The public has been able to appreciate—in comparing the deplorable results of the trial made on the Place du Théâtre Français with those which have been obtained at the Boulevard Poissonnière first, then on all the other roadways paved with wood in Paris—the enormous influence of a good or a bad system of wood paving; at London also there have been checks, but the Kerr system, the same which is at present employed at Paris, has entirely succeeded there, and is extending rapidly from day to day.

Colonel Haywood, whose favourable opinion of asphalte M. Malo has quoted, made, however, some reservations that M. Molinos himself heard him express. He admits that, for a trotting horse, asphalte is very inferior to wood paving; but Colonel Haywood is in charge of the public ways of the City. Now in the City the traffic is so great, that the vehicles always go at a walking pace.

Colonel Haywood then made the remark that asphalte in the City does not present the inconveniences with which it can be reproached in the streets where the horses are generally obliged to trot. In the whole of the remainder of London where the public roads are under the direction of Sir Joseph Bazalgette, the extension of the wood paving is considerable and continuous.

M. Molinos arrived finally at an important question, that of cost price. M. Malo asserts that the wood paving is dearer than asphalte. This is an error. It is a fact demonstrated to-day by experience, that for the most hardly worked roadway, for the Boulevards, for instance, the concrete foundation of 6 in. is absolutely sufficient with the facing of wooden blocks of 6 in. Under these conditions the price of the wood paving may be valued at 15*s.* 4*d.* per square yard. Now, this is the price of the asphalte of the Rue de Richelieu, and this ought to be the type of good asphalted roadways. If it is taken into account that in the price of 15*s.* 4*d.* the customs duties are included for the wood at the rate of 6*s.* per cubic yard, or about 1*s.* per square yard, it must be concluded that



far from being dearer than asphalte, the wood paving is rather the better bargain.

As to the maintenance, the price stipulated for the Boulevards is from 2s. per square yard per annum. But what would an asphalte roadway cost submitted to a similar traffic. Experience will allow this to be ascertained later on. For roadways of ordinary traffic, the cost of the maintenance of the wood can evidently be considerably reduced.

In summing up, M. Molinos thinks with M. Malo that the future of the paving of Paris is in the substitution for the hard and noisy stone paving, of roadways with a solid foundation, and an elastic surface such as asphalte and wood paving.

The price of establishing the wood paving is rather lower than that of asphalte.

M. Molinos believed that it was not yet possible to establish sure comparisons between the prices of maintenance.

As to the comparative advantages of these two

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systems from the point of view of the suppression of noise and of surety for the horses' feet, every one could appreciate them.

And, in concluding, M. Molinos would say with M. Malo, that there is at Paris a vast field of application where the two systems ought to find their place.

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MEETING OF THE 10TH APRIL, 1885.

The following letter from M. Léon Malo was read.

*To the President of the Society of Civil Engineers.*

LYONS, 2nd April, 1885.

MR. PRESIDENT,

I have been able to read only to-day the observations presented at the sitting of the 6th March, by my excellent comrade and friend, M. Molinos, on my communication relating to the roadways of Berlin.

In these observations, made moreover in the tone of the most winning courtesy, M. Molinos noted some errors which, according to him, had crept into my work ; he has discussed some of my calculations and rectified divers facts which have seemed to him inexact. I come in my turn to beg that you will have the goodness to allow me to insist on the perfect exactitude of my assertions. The crisis through which the Parisian public roadways appear to be passing at this moment, gives to this discussion an importance which does not allow of leaving the least part in uncertainty.

For greater clearness, I will follow step by step, correcting on the way, the emendations of M. Molinos.

M. Molinos commences by declaring that the asphalte is more noisy than wood. I never pretended that it was less. I concede also with pleasure to M. Molinos, that the horse's hoof resounds more on asphalte than on wood, in cold weather ; but the difference in the sound is so inconsiderable, in summer especially, when the asphalte always softens a little, that the people

living close upon it who are prevented by the noise from keeping their windows opened appear to me to have exceptionally sensitive hearing. I imagine that the solicitude of M. Molinos for these delicate persons has made him take the exception for the rule. That which is intolerably noisy on stone pitching is not the horse's foot, it is the rumbling of the wheel, and this rumbling, M. Molinos will surely allow, is as absent from asphalte as from wood. Besides, if the incomplete suppression of the noise of the vehicles is a nuisance to the immediate neighbours, its absolute suppression is a danger to the passers-by. The clanging of the horse's hoof on the soil is necessary to give warning of the approach of the vehicles, when the sound of the wheels cannot be heard. This is, I believe, the minimum of noiselessness that allows of safety to the pedestrian.

As to that which relates to the immunity attributed by him to wood paving against the spread of rottenness, I dare not share the hopes of M. Molinos. Without speaking of any of the signally disastrous experiences in London, Washington, and in Berlin, where some of the wooden roadways have been

entirely taken up in order to be relaid with asphalte (I willingly acknowledge that these transformations have not at present been very numerous), I believe I am right in asserting that the pine wood employed for this paving is always more or less moist and consequently more or less exposed to rottenness. I invite M. Molinos to visit after a storm, one of the crossways of Paris where wood is juxtaposed to asphalte; for example, the Place du Théâtre Français, at the opening of the Rue de Richelieu, where the two surfaces are exactly the same age. He will there see, two hours after the rain, the asphalte completely dry, whilst the wood will remain wet for two or three days even. M. Molinos will then surely decide, with me, that the water which has not been able to penetrate the asphalte, an absolutely impermeable material, has thoroughly impregnated the pine wood, an eminently spongy material, introducing therein elements, more or less active, of decomposition.

I hasten to add that, if I cite this fact, it is only to reply to the assertion of M. Molinos, and not in order to attack the system of wood paving, of which I have publicly acknowledged the great

merits and which I appreciate, not as the adversary but the ally of asphalte.

However, the eventual rotting of the wood paving does not disquiet me from the point of view of the deteriorations which it must cause to the roadways ; these contingencies ought to be foreseen by the contractor ; it is a simple question of maintenance. What preoccupies me above all, and what I have particularly aimed at in my communication to the Society, is the danger of the indefinitely repeated absorption of the atmospheric or pluvial humidity by the fibres of the wood and the influence of this absorption on public health. Also the permanent penetration of the impure liquids from the streets into this vast sponge, and afterwards their breaking out in the form of miasmata under the action of the sun. M. Molinos has not attacked this essential part of my criticism ; it is not, however, less important to discuss ; for there, in my opinion, is the weak point of wood paving. It is under the impression of this fear that I have expressed the desire to see wood paving, excellent (until a demonstration to the contrary) for highways thoroughly exposed to the air, to see it, I

say, rigorously excluded from the narrow streets where the circulation of the air is insufficient. The analytical account rendered of the sitting of the 20th February has not been able to reproduce in their fulness the observations that I have made on this subject. When M. Molinos shall have read them *in extenso* in the monthly *Bulletin*, I do not despair of inducing him to side with my opinion.

M. Molinos discussed afterwards the exactitude of the speech attributed to Colonel Haywood (not by me, who never heard it, but by the chief engineer, M. Barabant, from whose pamphlet I have restricted myself to quote), on the superiority of compressed asphalte, as far as the surface of the roadways of the city of London.

Colonel Haywood admits, said M. Molinos, "that for trotting horses, asphalte is very inferior to wood paving, and as in the City, he adds, the vehicles always go at a walk, the merits accorded to the asphalte by the celebrated English engineer would be singularly diminished."

I have voluntarily declared in my communication

that during the periods of fine rain falling on the muddy dust of the roadway, that is to say during an average of fifteen or twenty days per annum, asphalte becomes slippery. Asphalte is no more perfect than wood. But the remainder of the time when asphalte is dry or thoroughly washed, I do not believe that it is more slippery than wood. The reservations made by Colonel Haywood and pointed out by M. Molinos, refer without doubt to those periods of damp and drizzle more frequent besides at London than at Paris.

As to the pace of the horses in the city of London, it appears that I have not seen with the same eyes as M. Molinos; unless supposing that the cab-drivers have wished to flatter me, by abandoning themselves to fancy feats, each time that I have visited the City, I am obliged to believe that, so far from going at a walk, the vehicles travel there in a fashion to shame the Parisian omnibuses and cabs. M. Molinos has passed perhaps only in certain special streets, like Cheapside and Lombard Street, in which, at certain hours of the afternoon, the policemen are obliged to slacken the speed of the horses, and even to completely stop them, to



permit pedestrians to cross the roadway without danger. But Cheapside and Lombard Street are not all the City. There are other streets, also asphalted, where the vehicles move at a pace as rapid as anywhere. A man of sense like M. Molinos is forbidden to imitate the English observer who, disembarking at Calais and having encountered on the quay a red-haired woman, wrote in his notebook that all the French women have red hair.

It is, moreover, incontestable, as M. Molinos has said, that wood paving is extending considerably in the quarters surrounding the City; but it is just to add that these quarters, those at least which extend westward, are formed of large streets, straight, abundantly aired, bordered with low houses, traversing numerous squares, placed in a word in the conditions which I have indicated as necessary in order that wood paving should be inoffensive to the public health. Yet, in some streets (Oxford Street, Hart Street, &c.) wood paving has been suppressed to give place to asphalté. The local Boards of Works\* have decided

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\* M. Molinos makes a mistake in attributing to Sir Joseph Bazalgette the direction of the public roads of London outside

on this substitution principally in the interest of the hygiene of their quarters.

Another mistake, which M. Molinos makes and which I ought to rectify, not in order to fight against the system which he defends, but solely to show that I have advanced nothing that is incorrect, is this: "The wood paving works at Berlin have been confided without discernment to timber merchants without experience, who have executed them badly."

The truth is that not one timber merchant has

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the City. Sir Joseph Bazalgette is only director of the Metropolitan Board of Works, which solely occupies itself with great works of general interest, such as the embankments of the Thames, the sewers, and the opening-up of new streets. The questions of making new roadways as well as their maintenance, concern exclusively the engineers or surveyors of the parishes, save in the exceptional case where the piercing of a street traverses several parishes, which then contribute each its proportion to the cost of the first establishment. But, even in these circumstances, the engineers of parishes are always consulted on the nature of the materials to be employed. As for the rest, Sir Joseph Bazalgette has never done any paving in wood, but only paving in granite.

done any wood paving at Berlin. These works have been executed by four special companies :

1. The Improved Wood Paving Company (the same, if I do not mistake, which has introduced the system into Paris) laid in 1879 the first experiment tried at Berlin (Swedish pine unimpregnated) about 1200 square yards.

2. M. Guido Rütgers, of Vienna (Austria), a great wood-paving contractor, laid in 1881-1882, 9600 square yards of Bohemian pine.

3. An English company for paving with impregnated wood (its name escapes me for the moment) laid in 1882, 3600 square yards.

4. Finally, the Krafft Society, of Wolgast in Pomerania, great ship-builders and wood-pavement contractors, have laid 33,600 square metres of roadways of American yellow pine, a very resinous and unimpregnated pine.

In all 48,000 square yards, that is in course of being taken up at the present moment in order to replace it with asphalte.

Still once more, I do not intend to infer from this check any argument against the system of wood paving. Wood, like asphalte, has its flatterers and its faults; both have their experience to learn and their false steps. I have wished only to remind, by this example, M. Molinos that if asphalte does not pretend to absolute perfection, wood, even applied with all the care possible, ought not, any more than it, to claim infallibility.

I have now arrived at the question of price, and I am going, Mr. President, to take as a text the observations of M. Molinos in order to give you the information on this subject which you kindly, at the sitting of 20th February, asked me to furnish to the Society.

I said in that sitting, in a general manner, that compressed asphalte was, from the first establishing and maintenance, not so dear as wood; M. Molinos asserts that it is more. I am going to demonstrate to him, conclusively I believe, that he is wrong.

It will be so much the more easy for me in that I have nothing else to do than to allow the figures

to speak for themselves; figures drawn from authentic documents, taken publicly; from books of costs and price lists of the two enterprises charged with executing and maintaining, in Paris, the asphalte and the wood paving.

I quote then simply and literally these figures:

For asphalte of 2 in. laid on cement concrete of 6 in. (the thicknesses adopted by the city of Paris for streets of ordinary traffic) is paid, per square yard	s.	d.
.. ..	13	0

The maintenance of these surfaces, per square yard per annum (after twenty months' average free maintenance), costs to the city..	..	..	..	..	..	..	..	..	1	4
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In the exceptionally busy streets like the Rues Richelien, Saint Honoré, &c., for asphalte laid $2\frac{1}{2}$ in. thick on 8 in. of concrete is paid, per yard super	..	..	..	15	4
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The price of maintenance is the same as for the other streets, that is per yard *	..	1	4
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\* I recall solely from memory that the prices of establishing and maintenance are subjected to a discount of 2s. per cent. off fixed price.

The wood paving has been executed by mutual consent under the following conditions :

The paving with pine 6 in. in thickness,  
laid on cement concrete, costs, per yard *s. d.*  
super .. .. . 15 4

For its maintenance is paid, with a free guarantee of six months, per square yard :

	<i>s. d.</i>
For roadways with the heaviest traffic ..	2 0
For the others .. .. .	1 9

These prices are not diminished by any discount.

To resume :

The price of the first establishment of the wood paving is uniformly 15*s.* 4*d.* per square yard ; that is to say, the same as that paid for the exceptionally busy asphalte roadways.

It is 2*s.* 4*d.* more than that paid for the asphalte in the great majority of the streets of Paris.

The price of maintenance of the asphalte, per square yard per annum, is 1*s.* 4*d.*, that is to say,

8*d.* less per yard than the first category of wood paving, and 5*d.* less than the second.

The length of the free guarantee of wood paving is, on the average, six months, whilst the same guarantee for asphalte is twenty months; that is to say, that the annual payment for the maintenance of the wood commences to run six months after the construction of the roadways, whilst the asphalte is maintained during twenty months from the day it was laid, at the expense of the contractor.

And it does not follow that the price of maintenance, much higher for wood, corresponds to a much greater traffic on the roadway; for this traffic is proportioned not at all to the absolute number of vehicles, but to the number relative to the size of the street, also to the destructive action peculiar to these vehicles. There pass perhaps fewer carriages in a day through the Rue de Richelieu than on the great Boulevards or in the Avenue des Champs Elysées; but more certainly pass in the first of these ways, per superficial yard, and certainly also the vehicles which pass there are heavier and more dangerous for the preservation of the roadway.

Finally, M. Molinos observed that the wood paid on its entry into Paris 6*s.* octroi duty per cubic yard, being about 1*s.* per square yard of roadway.

I will reply to him that his argument is of no value ; for, within a few farthings, asphalte is submitted to the same charges. Actually, asphalte in rock or powder pays 6*s.* 4*d.* duty per ton. If I make the same calculation as M. Molinos, and if I apportion the amount of these duties to the square yard of roadway, I find, for the roadway of  $2\frac{1}{2}$  in. thick :

Asphalte per square yard . . . . .	<sup>d</sup> 7 $\frac{1}{4}$
Cement for the concrete, 9 <i>s.</i> 7 <i>d.</i> per ton ; or at the rate of 90 lbs. per square yard of concrete . . . . .	4 $\frac{1}{4}$
	<hr/> 11 $\frac{1}{2}$ <hr/>

A total which is not so very distant from the 1*s.* stated by M. Molinos.

It is not then correct to say that compressed



asphalte costs more than wood paving, the authentic figures that I have just quoted absolutely demonstrate the contrary, and M. Molinos would be the first to recognise it, if he would kindly re-read the documents from which I have taken my proofs.

Such is, Mr. President, the reply, too minute perhaps, but still necessary, that I had to make to the observations presented by M. Molinos. The vast transformation which is at this moment being worked in the Parisian public roads fixes on it, I have been able to convince myself, the lively attention of foreign municipal administrations. The authority which attaches to the discussions of the Society of Civil Engineers does not permit that in the debate opened here on this most important subject, we should allow errors to be introduced and accredited. This is why I have allowed myself to refute at such length those which I believed I discovered in the reply made to my communication by M. Molinos.

M. Molinos is an engineer too eminent, he occupies in our profession a rank too elevated and too merited, for this refutation to be able to hurt him.

He will accept it, I am sure, with as much good grace as I have taken the good faith and frankness to make it. He will not certainly forget, moreover, in this amicable and courteous contest, that the two adversaries are, after all, the advocates of the same cause,—the cause of the roadway of the future against the superannuated roadway of the past.

Kindly accept, Mr. President, the assurance of my most distinguished consideration.

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